Review

The Role of Different Types of Management Information System Applications in Business Development: Concepts, and Limitations

Hamed Taherdoost

University Canada West, Vancouver, Canada
E-mail: hamed.taherdoost@gmail.com

Abstract: Businesses are highly dependent on data to make critical decisions, manage operations, and simplify processes. Information systems equip businesses to gain benefits from data and provide easy and timely access to data through storing and processing input data from numerous resources. The majority of managers can deal with large amounts of data without letting it interfere with their ability to plan, organize, and control the organization. The disconnect between static information systems and evolving organizational structures is another primary factor contributing to information vulnerability. Organizational restructuring often necessitated revisions to preexisting information fixed systems to account for changing roles, responsibilities, levels of authority, and data requirements. An effective information system enables decision-makers in businesses to monitor trends, plan, predict measures prior to their competitors. The role of information systems to improve business performance has been investigated in studies considering the importance of relevant, accurate, and timely data. However, to increase the effectiveness of information systems, a comprehensive understanding of its applications and use cases of each type of information systems based on different organizational levels is required. This paper aims to provide concepts of information systems, present different applications of information systems, and discuss the main types of information systems based on their level of application. Specific types, roles, advantages, and limitations of information systems are also highlighted focusing on their impact on business developments. Besides, the impacts of different types of information systems on organizations and processes are provided.

Keywords: management information system, MIS applications, data processing systems, process control systems, enterprise information systems, decision support systems, executive information systems
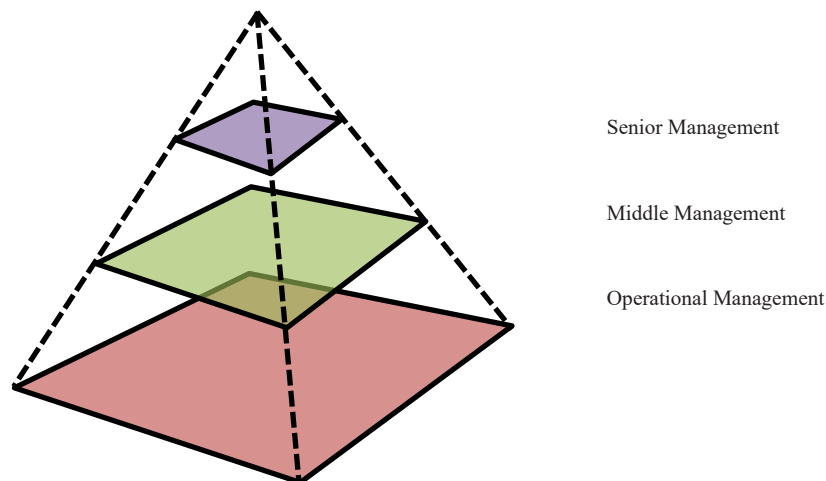
1. Introduction

A formal, sociotechnical, and organizational system for gathering, analyzing, storing, and disseminating data and other information is known as an Information System (IS). From a sociotechnical viewpoint, information systems consist of four parts: the job, the people involved, the structure (or roles), and the technology. What we mean when we talk about ''information systems'' is the integration of components for collecting, storing, and processing data for the purpose of delivering said information, contributing to said knowledge and delivering digital goods that aid in decision making. These systems support companies in important procedures such as decision making, controlling, analyzing

problems, and creating new services using a collection of people, data resources, networks, hardware, and software. In other words, the employment of information systems in a company provides the opportunity to improve efficiency, overall performance, and enhance the execution of business processes.

The basic structure of information systems is made of three fundamental activities which are mainly applied in the flow of all processes. Input gathers the raw data from both the company and its surrounding actors including all external objects such as suppliers, customers, and competitors interacting with the information systems of the companies. Then, the raw data is converted into meaningful and useful forms during the processing stage. Finally, utilizing the converted data by individuals or activities would be possible through the transformation process in the output stage. In addition to the basic activities, information systems also require feedback provided by returning output to the experts in the company to help them either correct or evaluate the input [1].

We can consider an organization as a series of levels with different information demands gaining IS support. The first level includes operating systems and service workers who receive the IS advantages to address their common transactions. Information systems benefit the second group to control, monitor, make decisions, and also to operate their administrative duties. This group with more special needs of information is called the management level. Finally, IS supports us to face the most vital difficulties which can even affect the future of the company. This supported level includes senior managers and administrators and is called the strategic level. The described organizational levels are shown in Figure 1 [1, 2].

Figure 1. Levels of management in organizations

The purpose of this study is to introduce the principles of information systems, describe the many applications of information systems, and examine the most common forms of information systems according to their level of application. In addition, the impact of specific information system kinds, functions, benefits, and constraints on the evolution of businesses is addressed.

2. Literature review

Information systems meet the expectations of information and data that are required at different levels of a business. For example, transaction information systems support lower-level demands of companies; however, management information systems provide data not only for the lower levels but also for the middle levels of administration [2]. In this paper, the main types of applications of information systems corresponding to the introduced levels will be studied. This paper also discusses a literature review on the impacts of these applications on businesses, and how the implementation of different information systems can help to improve profit and performance. Apart from a variety of

information systems, the main concern of this paper would be the following applications.

1. Data Processing System (DPS).
2. Process Control System (PCS).
3. Enterprise Information System (EIS).
4. Management Information System (MIS).
5. Decision Support System (DSS).
6. Executive Information System (EIS).
7. Transaction Processing System (TPS).

2.1 Data Processing System

DPS can be replaced both in the manual office procedures, and complex calculations in the new technology areas. These systems are one of the main tools utilized in the first level of a company where a huge volume of information is produced. In this section, two common DPS will be described.

2.1.1 Transaction Processing System

Dealing with the daily transactions of a firm makes the TPS a commonly-used type of system among data processing systems categories. As the basic business systems, transaction process systems serve the lowest level of the organizational hierarchy. These systems include computerized processes recording and performing normal transactions such as deposits, material flow, and sales in a firm [3]. On the other hand, updating information and controlling it in modern computer systems can be facilitated by implementing a TPS [4]. As a central part of systems, even a temporary breakdown in TPS can cause a failure at the company as well as other connected firms. In these processes, the security of online transactions is a serious challenge that should be considered [5]. This process utilizes a series of codes such as SQL or different programming software considering boundaries and specific constraints in both the first and endpoints of the processing system [6].

Generally, transactions through these systems happen in two ways. The transaction can be a batch process in which the gathered and stored is not processed instantly and it eliminates the operator to use the database in that stage. However, it can be also implemented utilizing online and immediate processes in which processed and output databases are accessible through real-time transaction processing. These two types of transactions are shown in Figure 2 [7, 8].

Duties, resources, and objectives should be outlined and structured at the operational level of a firm. TPS helps companies to achieve this goal and to answer the basic demands of organizations using available, current, and accurate information. For instance, a lower-level supervisor can decide to grant credits to customers evaluating whether they meet specific criteria or not. Tracking the flow of transactions through the organization, tracking the money paid to employees using payroll systems, and employee timesheets including their identifications and the number of hours they have worked; are other examples of TPS [1].

2.1.1.1 Impacts of Transaction Processing System on companies

Several studies investigated the role of TPS in companies considering different terms. For instance, Matsuoka and Muraki [9] implemented the TPS in permit-to-work procedures. They studied the role of TPS to ensure the effectiveness of a permit-to-work system in protecting workforces against perils in the energy sector. In the proposed framework, they represented a secure control system by eliminating the differences between the data that is stored in the system and substantial plant conditions. Their results showed that an effective permit-to-work system can be achieved by employing the new framework of TPS with the capacity to obtain granulated and isolated data processing.

In another study, a blockchain-based TPS was designed by Wang and Kogan [10]. In this study, a prototype was developed to investigate the usefulness of the blockchain-based TPS considering several objects such as fraud, monitoring, and accounting systems [11]. This specific TPS added a range of advantages to the system by enhancing information integrity, reducing transmission costs, rising transaction adjustment speed, and preventing deceitful and deceptive transactions.
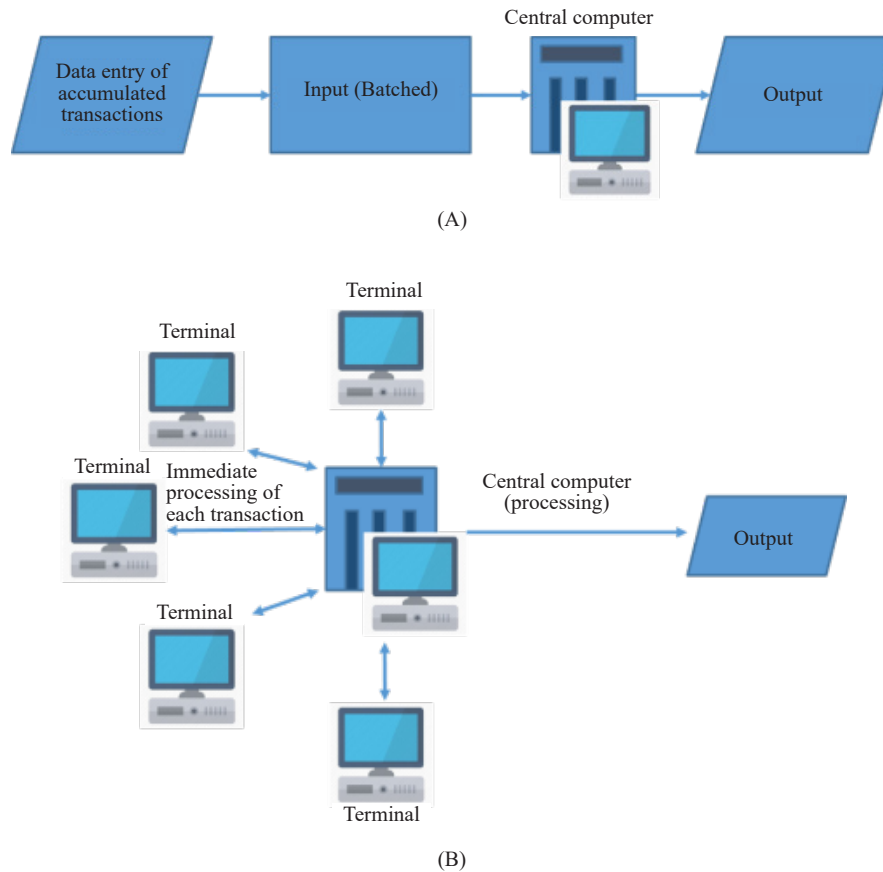
Figure 2. (A) Batch and (B) Online TPSs [7]

2.1.2 *Electronic Data Interchange*

Electronic Data Interchange (EDI) is an automated data exchange system that is replaced traditional paper-based ones. It enables systems to become more efficient and faster in internet-based and online transactions [12]. EDI utilizes the benefits of information systems by integrating the supply chain electronically. This integration of suppliers and distributors can help companies to reduce required resources to manage their information.

EDI helps computerized exchanges of the standard transactions among organizations. These qualities can support both companies and customers in different services such as ordering processes which can be directly possible between the internal systems of the customer and the resource without any other mediators in normal manual services [13]. A network is used with the purpose of automatic transmission among information systems. Using the EDI systems, the company can also simply place an order via the computer and when they want to run an ordering process again, it is ordered without requiring any manual ordering [14, 15].

Take the purchasing system in an ordering process as an example. In traditional systems, an operator must confirm the order through the first information system, send the printed order to the supplier using fax or email, and then another side accepts it in similar way. On the contrary, in advanced systems, all these extra stages are eliminated through EDI and a direct and unified transaction network. All these can create many advantages to the transaction such as reducing the executive/implementing cost and errors, enhancing the employees' efficiency, and the security of the transactions [16]. Figure 3 shows the ordering systems for a common manual process and an EDI-based system [12].
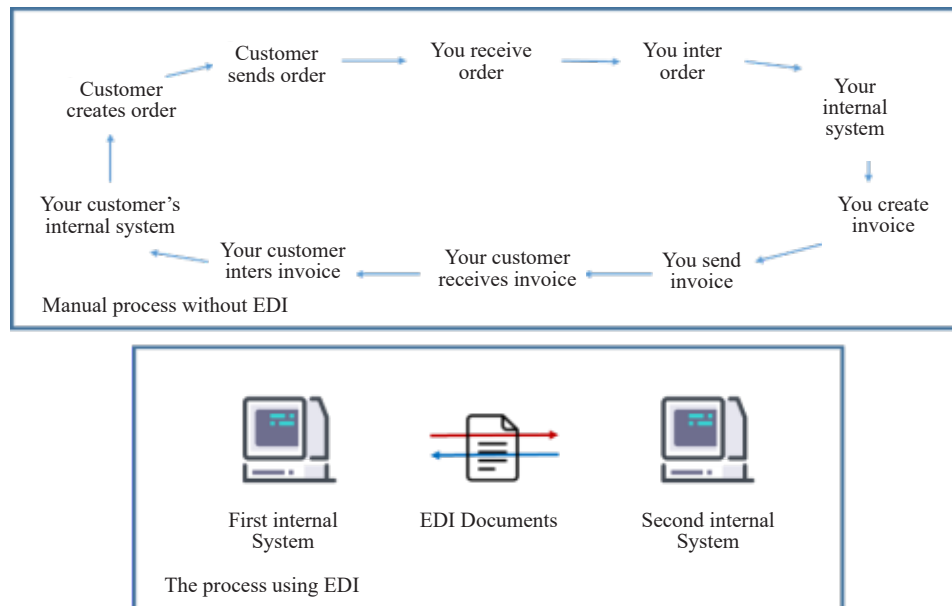
Figure 3. Manual and EDI ordering processes [12]

2.1.2.1 *Impacts of Electronic Data Interchange systems on companies*

EDI facilitates businesses to process commercial documents that are sent and received electronically such as bills, and invoices between computers, and eliminates the need of writing and mailing them physically. This positive edge can bring a competitive advantage to companies, reduce costs and strengthen the commercial connections with suppliers, customers, and other co-workers in a business [14, 15].

O'Callaghan et al. [17] investigated the implementation of a specific form of EDI. The results of the study demonstrated the value of adding EDI to channel relationships in terms of increasing the transaction processing efficiency, facilitating manufacturing and marketing systems, and enhancing the coordination and communication systems. Erank and Marchewka [18] utilized a case study approach to examine the development of EDI applications by a consulting company. Several individuals in the company considered the system as an opportunity for the generation of new revenue. However, in some viewpoints, it was not a potential system with sufficient profitability and could not be translated into more duties.

2.2 *Process Control System*

Another common type of data processing that serves both operational and technical levels is known as a PCS. PCSs are utilized with the aim to monitor and control different physical and industrial processes ranging from operating systems and computer programs to equipment. Although hardware control systems functions are utilized in the majority of control systems in the processes, the growing trends through efficient software systems cannot be denied. These installed information systems can be different software systems including small, large, x preface freestanding types, and also connected systems using networks all through the processes.

Employment of key qualities of PCSs based on databases can lead to fundamental effects on the capacity of the system extension and response time [1, 19]. These systems help organizations to attract and process high volumes of information; obtain high precision of data processes and have the ability to execute complex calculations in their processes. These systems can be utilized in different industries such as power plants, manufacturing chemicals, and oil and gas refining systems. These processes use computer-linked sensors with the ability to continuous monitoring together that provides regulations and adjustments to achieve a defined condition for each system [3].

2.2.1 *Different types of Process Control Systems*

PCSs are categorized mainly as programmed process control, manual operation process, analogical, and supervising control systems. Programmed process control systems are utilized in large industrial sectors for start or stop process systems to control the qualitative transformations considering both the real-time and minimum attracted energy in a series of operational progressions.

In the manual operation process, human operators support the process of manual adjustments by measuring and displaying the values of the process variables. To eliminate human interference, analogical control provides automatic corrections by monitoring the output variables and changing input variables to obtain the designated levels in the system. In complex industrial processes, there are a great number of analogical loops, and in these sectors, computers are replaced with conventional analogical loops. In this direct digital control system, computers calculate the values of the necessary input variables and transmit them to the processes. Finally, supervising control systems use the help of computers to optimize the performance indicators of the process goals. These superior control levels include the operating of the process level in a control system instead of other control methods that computers operate directly in the process [20].

2.2.1.1 *Impacts of Process Control Systems on companies*

A type of supervised control system was used by Aubrun et al. [21] in a particular process to control the conditions of the operating systems together considering the special limitations of the production. Mandel et al. [22] introduced an expert-statistical data processing approach to developing control systems. They used a new adaptive model in the system to support decision-making and process forecasting. Their proposed models can be used in the inventory control algorithms considering the minimum total average costs during the planning period.

In another study in 2020, to enhance the chemical security in the system, Straut and Nelson [23] studied different pillars such as material control to address the chemical security in the system using a Chemical Inventory Management System (CIMS). Their findings demonstrated that the CIMS can develop the system by decreasing the safety and security risks alongside managing time and laboratory resources.

2.3 *Enterprise Information System*

Integrating different types of systems can be a key challenge in an organization, and implementing enterprise applications can be considered a promising solution in this regard. These systems help companies integrate business procedures tightly as well as integrating groups of different processes by focusing on increasing the efficiency of customer services and resource management which are described in the following section.

2.3.1 *Enterprise Resource Planning Systems*

Integrated management of resources in a company is possible through the employment of Enterprise Resource Planning (ERP) systems. Companies can gain several benefits through utilizing ERP systems. They can enhance the accuracy of their decision-making processes and automate their activities. Access to the information at the exact time is also another factor that can be achieved by ERP systems.

Generally, a series of integrated software modules work with a central database to provide a sharing system in an ERP system. Thus, the input data by one part can be instantly available to other processes. The database system gathers data from different departments and fundamental business processes such as finance, accounting, human resources, and sales. This accessible data leads to the centralization of the database as the key to the success of an enterprise resource planning system for the instantly available data characteristic [1].

Enterprise collaboration systems are also recognized as office automation systems which are one of the widely used groups of enterprise systems. These systems are employed to help managers with different tasks. Managers can perform sharing processes more efficiently by utilizing collaboration systems. This can also help to gain higher communication between the company groups and workers and control the information flows and different office duties ranging from electronic mail to video conferencing and file transfer [3].

As discussed, the benefits of enterprise resource planning systems are by no means negligible. However, there

are some limitations as they cannot cover all processes from all industries, and many businesses need to use specific solutions for their company. Using ERP systems makes different issues ranging from technical viewpoints to business aspects. An important limiting factor is the inflexibility of resource planning systems. Adopting these types of systems ends with standard designed processes for organizations due to the requirements of implementing these systems. Nevertheless, this problem happens through less expensive ERP systems with a short implementation period and less parameterization. A more developed ERP system requires a long implementation period which makes it another major criticism of ERP systems. It can last even for three to five years in large companies. Another limitation happens since ERP Systems work based on assuming the managed centrally information and well-defined hierarchical structures companies. However, ERP can be utilized for each of the company's units, and consequently, it is possible to overcome the proposed limitation where that situation does not occur. The application of outdated technology, not being user-friendly (since they do not make graphic and modern interfaces), and not offering benefits for integration in some current object-oriented ERP systems are other limitations of ERP systems [24]. On the other hand, AboAbdo et al. [25] investigated an ERP system in a large firm to analyze the significant factors affecting the performance and efficient implementation of ERP systems. According to the consequences, several human factors including user training and support, involving top management, and team configurations can be effective in ERP results [25].

2.3.1.1 *Impacts of Enterprise Resource Planning System on companies*

ERP can be beneficial in different aspects for companies. The positive impacts of ERP systems were investigated by Aslan et al. [27] on Make-To-Order (MTO) organizations. They used a mixed-method study and showed that firms utilizing ERP systems can enhance the use of project planning tools, and make more efficient management and planning procedures [27]. The results also demonstrated that more applicable benefits can be gained in these companies in case of using the strategies of production. Hietala and Päivärinta [28] focused on the continuing benefits known as post-implementation of these systems in a case study. They demonstrated benefit realization practices as a significant factor to enhance job satisfaction gained through ERP utilization.

2.3.2 *Customer Relationship Management Systems*

When companies achieve constant contact with their customers through customer services, they can plan to improve the services required to improve customer satisfaction which can, in turn, influence their achievements positively in terms of efficiency and portability of the companies. They also need to address different requirements in their company such as system, information, and service qualities to gain this goal. It is how IS can improve customer services [29].

The optimization of revenue, customer satisfaction, and retention in companies is possible through implementing Customer Relationship Management (CRM) systems. Customer relationship management helps companies to achieve a strong and long-lasting connection with their customers. CRMs organize the companies' processes such as marketing, services, and sales administering with customers using their provided data. In other words, IS-based CRM employs customers' data and its main focus area is more specifically on two major groups: current customers and beneficial new customers. For the former group, providing better services is the purpose of using information, and for the latter, information is used to identify, attract, and keep them connected to the company. All these activities help organizations to increase their sales [1].

Companies can cross both internal and external borders to increase the efficiency of their operations by implementing CRM. For this purpose, the CRM system helps to collect and integrate data about customers, and then the results of analyzing the customers' data using CRM software can be considered as the communication method between the business and its customers.

2.3.2.1 *Customer Relationship Management projects and functions*

Planning and implementing a set of small CRM projects in the process leads to CRM strategies. These Projects are settled into three main groups: Operational, analytical, and application CRM projects. Addressing the functional and technical requirements of CRM strategies can be obtained using operational CRM projects. To get a comprehensive

understanding of customers' behaviors, expectations, and needs are the objects of analytical projects. Finally, application projects focus on enhancing customer relationships and marketing decisions by employing the outputs of operational and analytical projects [30].

CRM function tools such as large-scale enterprise systems, offer different capabilities, applications, and modules to help companies in performing their strategies. They provide different services ranging from customer and marketing to customer complaint gathering systems. While customer services use the updated customers' information to gain an efficient service and support system for customers, marketing modules analyze data tools that are used in different parts such as bundling, cross, and up-selling, recognizing modification possibilities in products and services. Sales Force Automation (SFA) system is another application that focuses on identifying customers considering their high profitability. These systems help firms by providing applications and modules for different purposes including customer service, marketing, Sales Force Automation (SFA), and receiving customer complaints [19].

2.3.2.3 *Impacts of Customer Relationship Management Systems on companies*

CRM systems have been studied in different academic papers. King and Burgess [31] studied the components impacting the failure and success in CRM systems. First, they discussed the benefits of utilizing CRM systems for companies in terms of ensuring better customer targeting and insight, increasing sales, and improving service. Then, focus on the elements to avoid failure in CRM systems. For this purpose, they converted a developed conceptual model of CRM into a dynamic model. The beneficial effects of CRM on organizational support were gained as a result of their study.

The impact of CRM employed in businesses using information systems was discussed in a study by Ku [32]. This study adopted a survey using 552 mailed questionnaires to 58 international hotels. Analyzing the results showed that the quality of the information provided by IS, the orientation of services and processes can affect CRM profitability. They also formulated a CRM profitability model considering the perspective of system efficiency.

The roles of CRM systems on company accomplishments were studied by Haislip et al. [33]. They investigated different possible benefits for companies adopting CRM systems. The positive impacts of CRM on the operational factors of the companies were achieved as a finding and also, they particularly identified the developments in efficiency, operational performance, and profits. They mentioned that CRM systems can help organizations increase sales and operate cash flows, reduce both the operating boundary and suspicious accounts, and generate more authentic predictions for their benefits.

Li et al. in 2019 [34] examined the usefulness of CRM systems in businesses. A novel model was utilized to evaluate the benefits of CRM on firms. They demonstrated the benefits of operational CRM by positive impacts on the revenue per worker. This item also can cause high profitability and market assessment.

2.3.3 *Supply Chain Management Systems*

A series of connected organizations working to add value to the input through different procedures to gain the needed output is the supply chain. A supply chain includes two different streams. The upstream is all the direct and indirect company's suppliers and their management processes. On the other hand, downstream contains other parts such as product and goods delivery systems.

Supply Chain Management (SCM) is a complex concept; however, it is simply parallel with business management by considering the factors of the supply chain which include the whole flow of the process from the first supplier to the endpoint. Generally, it aims to address the requirements of all integrated supply chain parts with less cost and more satisfaction level [35]. Supply chain scale and complexity are issues since complex organizations need to adjust a huge number of activities such as orders, deliveries and consequently they cannot manage these activities through common ways as easily as small companies. In this case, managing and addressing problems of these complicated systems are the role of SCM systems.

As a network connecting processes in a company, the supply chain in a firm offers different benefits. It helps to secure raw materials, convert them to the middle and final production stages, and distribute the final goods to customers. This inter-organization system automates the flow of information over organizational boundaries. SCM also helps suppliers, purchasing companies, distributors, and logistics firms with more efficient sources, products, and delivery

of products and services. However, the basis of productivity of all these processes is sharing information through information systems. In addition, implementing information SCM systems helps to enhance the profits of the company by reducing different costs such as producing and transferring goods, and facilitates making wiser decisions in the terms of managing the supply chain sections [1].

2.3.3.1 *Supply Chain Management system decision-making process*

To develop a successful SCM project, managers should pass three different stages. First, they need to recognize the members and links in the supply chain [36]. The important point in this stage is that considering all members is not possible due to the limitation in different sources such as time. Managers should consider the most vital partnership levels to choose their goal members. The second stage is the integration of the processes and members to fulfill orders. These joint processes can be different ranging from customer relationship processes to return services. The final stage is identifying the integration levels. Different elements can gain management support. The first group is technical and physical components such as different structures for facilitating the flow of goods, information, and communications. This group contains measurable and easy-changing qualities. On the other hand, behavioral and managerial elements such as the corporation of philosophy and management affect the implementation of the first groups and strengthen the behavioral aspects of the company [37].

2.3.3.2 *Impacts of Supply Chain Management systems on companies*

In a comprehensive review, Fiorini and Jabbour [38] investigated utilizing IS to assist companies in gaining sustainable SCM systems. They reviewed different papers, and demonstrated IS to be an important and supportive tool through supply chain management that benefits the companies, suppliers, and customers. Their results showed that these systems positively can impact the financial, environmental, and operational performances of the companies. The study by Nürk [39] also dedicated to the ability of information system-based SCM systems to obtain promising business performances.

Then, they should identify the relationships between processes and chosen members. These business processes can include customer relationships, demands, orders, and return processes, and are used to integrate with their related members to meet supply chain targets.

The integration and management level is also another key decision during supply chain management. Alongside different components that can gain managerial support, physical and technical components that are measurable with flexible values, and on the other side managerial and behavioral components can affect the first group's implementation [37].

2.3.4 *Knowledge Management Systems*

If the creation, production, and delivery procedures work based on superior knowledge, a company's performance can be better compared with its competitors [3]. Effective management of knowledge can enhance the performance and innovation of the companies, and companies should utilize secured and controlled knowledge to reach these goals. Companies are vulnerable to losing their knowledge, and also can be directed to the inadequate processes and systems to store, create, use and share their knowledge that is so significant for long-lasting continuation. Information systems can be considered key tools to face these demands by the concept of Knowledge Management Systems (KMSs) [40].

Relevant and comprehensive knowledge and experience can be gathered from internal or linked external knowledge sources through the employment of these information systems. This available knowledge can support companies to enhance their decision-making and other critical processes in their business. Furthermore, these systems are closely related to collaboration systems. Therefore, communicating and sharing knowledge is an essential aspect to make these systems appropriate and useful [1].

Knowledge-based information includes qualitative and quantitative reports of previous project experiences and can add the lessons learned during those projects to the companies to assist them to address their issues during other difficulties. A simple process perspective of a KMS including different technologies, forms, and functions is shown in Figure 4 [41].
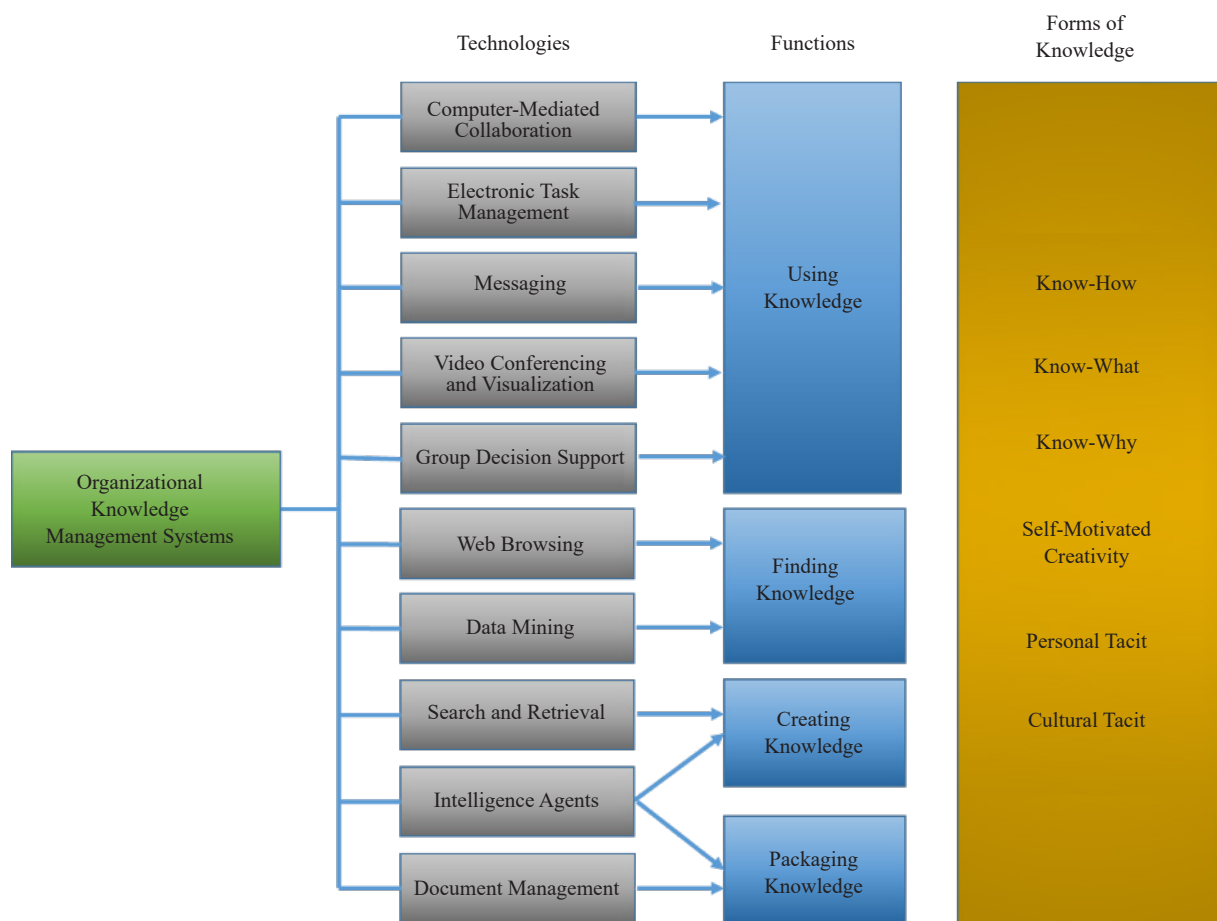
Figure 4. A simple perspective of KMS [41]

2.3.4.1 *Impacts of Knowledge Management Systems on companies*

Information Systems develop knowledge management in different aspects. KMSs assist to gain easy and quick available external sources and intensive new communication channels. Information KM systems also protect systems against memory loss and help knowledge capture processes such as post-project reviews and debriefings from online sources. Also, the impacts of these systems on identifying and recognizing potential markets and innovations in products and processes can add value to the company's sales and profits. The operational management enhancement is also reported as an undeniable benefit of KMSs in the literature [40]. Choi et al. [42] investigated the performance enhancement of a company by using a knowledge management system. They applied different KSM strategies and by utilizing a complementarity theory proved that implementing KMS has a positive effect on performance. Centobelli et al. [43] suggested managerial tools to ensure the efficient and effective adoption of KMSs in their study.

2.4 *Management Information System*

MIS are critical tools in all companies. They aim to quickly prepare information in terms of specific characteristics such as being complete, reliable, understandable, and accessible. These systems tend to automate duties and enhance the productivity, effectiveness, and efficiency of the processes in an organization. In other words, automation can help companies in saving different resources including workers, money, and more importantly time [44].

At the second organizational level, MIS supports the controlling and monitoring of the TPS transaction procedures

that occur at the office level. For this purpose, the TPS collected data is utilized in MIS to provide the required control reports for administrators. MIS integrates different science aspects using a realistic adjustment to develop solutions for the systems. Computer, management science, and operation studies make the roots of an MIS process. In an MIS model, a database provided by information systems is utilized by software to achieve periodic reports and mathematical models. These models are used to simulate the processes in the company. Then the output of the simulation process can help managers to solve challenges in the company. In these models, when the decision-makers are in the organizational environment, the management system presents information to the other members of the Inter-Organizational Information System (IOS) [1, 2].

2.4.1 *The roles of Management Information Systems in decision making*

Decision-making processes can employ both main and sub-management information systems for many basic purposes. For instance, they can extract integrated information from a massive database to assist decision-makers. Organizations can make decisions both to improve their operations or to select new business opportunities to obtain maximum profit. Generally, the role of MIS in decision-making processes can be considered as:

First, the required information of decision-makers is provided using MIS. All managers access the computer using a system that is a formal engagement by executives. In other words, MIS adjusts a solution to fulfill other areas like decision support systems and knowledge-based systems.

Second, by using information with continuous supplies to the managers, the MIS helps companies to identify and understand the problems of systems, and analyze circumstances.

MIS as a day-to-day management system brings along several advantages to the business by providing appropriate answers to address business issues, an efficient and effective association among companies' sections, and providing relevant data and documents. They also reduce the demand for time and labor, improve organizational and departmental techniques, and replace the manual filling and analyzing processes with quick and easy computer systems. All these benefits can cause more effective controlling, organizing and planning systems. Therefore, the vital role of MIS in businesses cannot be ignored. Nowadays, the way that managers plan, decide, and organize their workers, as also the essential decisions in the product's processes are directly affected by the organizational management information systems.

In addition to contributing to the discussion surrounding the role of MIS in enhancing decision-making, Rhodes argues that management information systems provide quick access to information for managers. This may include interaction with other decision support systems, information requests, external information cross-referencing, and possible data mining techniques. These systems can also compare strategic objectives to practical decisions, providing managers with a sense of how well their own decisions align with company strategy. In conclusion, Rhodes feels that management information systems are a significant role in the acquisition of reliable data from enterprises. Sadly, few organizations have been able to enthusiastically assume this position and even serve as a model for other organizations in society. Because of this, the improvement in decision making based on the customization of useful information has been limited. In the section titled "Recommendations", a straightforward approach to resolving this issue is provided [45].

2.4.2 *Impacts of Management Information Systems on companies*

The benefits of these systems such as providing useful, on time, and correct information, cost-saving processes, and employee productivity can highlight the MIS importance [3]. Singh and Kaur [46] described different opportunities obtained using MIS which also can cause better performance for decision-makers. Some of the important considered opportunities were economies of scale due to the lower cost of operations, obtaining more information using the same data which can help a better decision making. Another study in 2014 examined the role of MIS in telecommunication companies in Yemen. The positive impact of MIS in collecting, storing, and processing the data and also regaining needed information can enhance the efficiency of the companies [44].

Kock et al. in 2020 [47] investigated the positive impact of a particular MIS on the performance of companies. They used a project portfolio MIS in their study to enhance the quality of the management process which can facilitate the improvement of the portfolio performance as well.

2.5 Decision Support System

If company schedules were delayed for a couple of months, what would happen to the return on their investment? What would be the impact on production schedules, when an organization decides to achieve higher sales in a particular period? Decision Support Systems (DSSs) try to answer these types of questions.

As a computer-based system, the focus of DSS is on solving unique and fast-changing problems and achieving a solution for these kinds of issues that cannot be recognized by the system. Interactive DSS software-based systems aim to use collected and gathered information from several resources such as documents, raw data, business models, and individual knowledge to assist managers in decision-making procedures to identify and address their problems [48].

Although MIS can identify system issues and help decision-makers to choose and evaluate correct and suitable solutions, the particular and special needs of the decision-makers cannot be met by MIS. According to this limitation and the failure of MIS in preparing the exact required information, DSS suits these particular requirements for the individual and also groups of managers. Thus, this quality adds value to the decision-making process in comparison to common decision-making systems, and consequently, managers can gain more power to make special decisions such as plan explanation, new goods, and marketing [2].

DSS utilizes both the information internally achieved from TPS and MIS and also external sources, for example, the prices of current stock and competitor's goods. Using this comprehensive information, DSS can estimate both technical and financial-related details for the companies. For instance, a DSS-based system for the voyage estimation systems in a transportation company can calculate the costs of ship/time for employees, and port distances for financial and technical calculations, respectively. They can address more specific questions such as the relationship between the speed of the vessel, delivery programs, and overall earnings to optimize the proposed system considering specific criteria [1].

2.5.1 Elements of a Decision Support System model

Different specific parts work together in a DDS to gain the objectives of the system.

- Databases: First and the most basic part of a DDS, is implementing the database to store data from different resources.

- Software: The reports are written using software using procedural languages such as PL/I. Although, more advanced languages can be utilized to provide special reports as database forms to face the unpredicted and unforeseen information needs.

- Models: Different functions such as operational facts or physical systems can be simulated in the forms of mathematical models to provide information in another way. Using special model languages can make the writing of a mathematical model easier with a better potential of doing its functions; however, they serve the possibility of using a common procedural language for programming [2].

- GroupWare: This system is the basis of group decision-making processes. A Group Decision Support System (GDSS) works as a part of this system to support more than one decision-maker representing multiple decision experts or committees in the same or different locations, and reaching the solutions together and as a team. These interactive and computer-based systems help to address unstructured issues by a project team communicating both directly, and utilizing the groupware [1]. The reports writing software and mathematical model are considered essential DSS ingredients. However, the groupware element becomes a reality when DSS supports multiple decision-maker experts as a team committee.

Several scenarios with different usefulness degrees can help to express decision models. They apply developed and accurate fuzzy models including multiple criteria for the methods of decision-making. The moderator can be replaced in the concurrence processes by the employment of a specific web-based DSS where specialists can implement options themselves [2].

2.5.2 Different frameworks of Decision Support Systems

DSSs are different with several specific characteristics. The more common frameworks are discussed here. The ideas can be saved as electronic notes using a text-oriented DSS locating them into different separated text files. It

allows them to create, update, view documents electronically when it is required. Since the knowledge in the text files is not connected, utilizing this framework limits the user by tracing a huge volume of ideas which is not convenient. This issue due to the discussed obstacle can be solved using hypertext-oriented decision support systems.

Hypertext-oriented DSS gives the administrators a high capacity for storing and recalling processes by managing huge amounts of connections and ideas by linking the conceptually related text pieces to each other. Therefore, the decision-maker is not persuaded to memorize personally and database-oriented support systems developed by the database technique of knowledge management are another DSS case. These systems contain organized and highly-structured data instead of managing data as streams of text.

The spreadsheet-oriented DSS technique for knowledge management supports users with gathering information in spread-sheet forms. This system helps in different knowledge procedures such as creating, storing, and modifying. Also, gaining independent directions is a possible option that can provide decision-makers with more ability to control the technical knowledge compared to the text or database management systems.

Another type of decision support system is the solver-oriented system with a focus on the notion of solvers. Solvers can be combined with DSS utilizing fixed and flexible approaches. The fixed approach does not give the possibility of being easily added, modified, and deleted to the solver, and a solver is considered a fixed term in the DSS. To address this limitation of a DSS, a flexible approach can be a rational solution. In this approach, it is possible to manage solvers according to user requests. These solver-oriented algorithms help to address special programs and practical calculation types in the systems.

Rule-oriented DSS represents and processes rules. Managing reasoning knowledge is possible for computers through implementing these systems emerging within the artificial intelligence field by considering valid conclusions when a certain circumstance happens. It means these support systems follow specific methods which are adopted as rules. A basic form of rule-oriented DSS can be considered as a combination of rules based on a premise, conclusion, and reason according to the specific situation. Since rule-oriented DSSs follow the human expert nature, they can be known as expert systems as well. When human experts are not cost-efficient, consistent, or available, this expert DSS is especially worthy.

Finally, compound decision support systems help to use different types of systems together. All discussed frameworks tend to implement different techniques by emphasizing one knowledge-management method. These types serve decision-makers in specific ways which are not replaceable with other ones easily. Two separate options are possible in the cases that decision-makers want to use the offered support of multiple knowledge management methods. The first one is using multiple DSSs based on different techniques. On the other hand, a single DSS containing multiple methods can be utilized. These cases can be achieved using integration approaches (conversion, clipboard, and confederation) across decision support systems.

2.5.3 *Impacts of Decision Support Systems on companies*

DSS serves companies several benefits in the decision-making process by easing different limitations and eliminating their related issues. It supports gaining more productive solutions together with enhanced satisfaction, also greater agility, innovatively, and reputably through decision-making processes [49]. Erozan [50] reported a fuzzy DSS with more practical effects on the reliability of the components in comparison to common reliability functions. A system can be improved when the maintenance works especially for more crucial components that can be applied reliably and credible. Guo et al. [51] in another study, used data mining technology in a particular decision support system. The results of data mining technology in the proposed system showed that this system can analyze multiple aspects of statistical data which provides better and more satisfactory decisions.

Teerasoponponga and Sopadang [52] investigated DSS in the food sector considered a medium-sized industry. According to their results, DSS can assist to choose the suppliers and the quantities of optimal orders. On the other hand, DSS can help to manage inventory policies in specific situations, together with considering different criteria such as sales promotions and material availability. Finally, DSS can decrease the costs of raw materials and on-hand inventory and also reduce order intervals in the company.

2.6 *Executive Information System*

A senior manager of an organization should make appropriate decisions to address the challenges of the company together while considering the time limits due to the growing competitive atmosphere in business. For this purpose, providing the required information needs a variety of tools known as Executive Information Systems (EISs). Flexibility is an important and particular character of the EIS helping to adapt to the changing issue types, and information needs [53].

Assisting senior administrators in focusing on the most vital information with the direct effect on the company's success, overall efficiency, and profitability, is another main aim of applying executive support systems. Senior managers use these developed systems to face the company's unplanned and infrequent decisions which require insight, judgment, and assessment. Quick access to a variety of internal and external needed information (from TPS, MIS, DSS, textiles, financial reports, commercial sources, etc.) and by presenting easy-to-use and understandable data and graphs is possible through utilizing these particular IS systems [1, 54].

The difference between DDS and EIS is derived from what they support. DSS supports the upper management system indirectly since the intermediates often have the responsibility of preparing the executives' requested analysis. Furthermore, decision support systems are restricted in scope and focus on a particular decision. Thus, a DSS can face a failure to prepare a comprehensive view of the company compared to the EIS decision-making [55].

As discussed, EIS aims to prepare the most vital information with a direct effect on the company's success, overall efficiency, and profitability. Therefore, developing EIS includes two parts, first a methodology for diagnosing what is exactly "the real vital information" for a firm and then developing capable systems to deliver the essential information to the right administrators in an appropriate timescale [1].

2.6.1 *Advantages and disadvantages of Executive Information System*

Employment of EIS serves several benefits for companies. Since the operation of these systems does not require extensive computer experience, these systems are easy to use for administrators. EIS can timely deliver the company's summary information. It provides easy-to-understand and filtered data for managers. EIS also helps to enhance tracking information and offers decision-makers a more efficient performance. On the other hand, executive information systems also possess some disadvantages. EIS is system-dependent, and insufficient functionally, by design. These systems have high implementation costs, with overloaded information for some managers. The management of these information systems can face difficulties due to the possibilities of hard, large, and slow procedures. EIS requires appropriate internal procedures for managing data and sometimes the provided data can be insecure and less credible [8].

2.6.2 *Impacts of Executive Information System on companies*

EIS is applied in many areas ranging from typical corporate hierarchies to personal computers on a local area network. For instance, in companies working on customer services, using the developed information systems helps workers to utilize their personal computers to obtain organizational data [8].

Using a well-designed executive system can assist senior executives to audit the company's performance, identifying the changes in market circumstances, finding the problems as well as opportunities, and it also helps to track competitors' activities [1]. Florentino and Joyanes [56] investigated the effects of EIS in an insurance organization in Portugal. In this research, they discussed the positive impacts of implementing these systems in different aspects including productivity and work quality. They also reported that sales and the number of logins on EIS are directly linked positively.

Azad et al. [8] reviewed different aspects of EIS. According to their research, EIS provides senior executives with several abilities by offering different internal and external detailed data from financial markets to economic information. On the other hand, marketing executives' main role is to ensure an effective future for the companies. To achieve this goal, they should act judgmental against the uncertainties and risks of plans and their impact on the organization considering permanent and temporary aspects. Also, this IS system is employed to help their growth by providing an approach to sales forecasting using past sales.

Table 1. Summary of information system type and their impacts

Type of IS	Sub-Groups	The Impact of IS	References
Data Processing Systems	Transaction Processing Systems	Obtaining the effectiveness of permit-to-work systems.	[9]
		Enhancing information integrity, reducing transmission cost, rising transaction settlement speed, and preventing fraudulent transactions through Blockchain-based TPS.	[10]
	Electronic Data Interchange	Increasing the transaction processing efficiency, facilitating manufacturing and marketing systems, and enhancing the coordination and communication systems.	[17]
		EDI provides the opportunity to generate new revenue. However, in some viewpoints, it was not a potential system with an adequate profit margin.	[18]
Process Control Systems		Gaining appropriate control operating conditions together alongside respecting the limitations of the production.	[21]
		Supporting decision making and process forecasting; implementing control algorithms considering the least total average costs during the planning period.	[22]
		Decreasing the safety and security risks at the same time alongside with time and management resources.	[23]
Enterprise Information Systems	Enterprise Resources Planning Systems	Improving the application of planning tools using ERP.	[26]
		ERP implementation can be highly impacted by human factors.	[25]
		Increasing job satisfaction considering the constant benefits of using ERP.	[28]
	Knowledge Management Systems	Identifying and recognizing market opportunities, operational management, and innovation through employment of IKMS.	[40]
		Increasing organizational performance.	[42]
		The study suggested managerial tools to ensure the efficient and effective adoption of KMSs.	[43]
	Customer Relationship Management Systems	Ensuring greater customer insight and targeting, improving services, and increasing sales.	[31]
		Formulating the CRM profitability model based on the perspective of system efficiency.	[32]
		Enhancing the efficiency, operational performance, and profit forecasting process.	[33]
		Positive impacts on the revenue per employee can lead to high profitability and market valuation.	[34]
	Supply Chain Management Systems	SCM can positively impact the financial, environmental, and operational achievements of the companies.	[38]
Management Information Systems		Obtaining superior performance by utilizing SCM systems.	[39]
		Enhancing the efficiency through the positive impact of MIS in collecting, storing, and processing data and also retrieving required information which can enhance the efficiency of the companies, productivity, and cost reduction.	[44]
		A lower cost of operations and a better decision-making process.	[46]
		Enhancing the performance of companies and the portfolio.	[47]
Decision Support Systems		Providing more productive solutions, enhancing satisfaction, greater agility, innovation, and reliability through decision-making processes.	[49]
		Gaining more credibility to manage the tasks.	[50]
		Making better decisions that lead to improving the performance of the company.	[51]
		Decreasing the costs of raw materials and on-hand inventory and also reducing order intervals in the company.	[52]
Executive Information Systems		Enhancing productivity and the quality of performing tasks.	[56]
		Creating a more effective future and providing an approach to predict sales.	[8]

3. Discussion

This paper has provided different applications of information systems considering the levels of organization services. For this purpose, we described six main types of information systems in detail considering different categories for some applications. Finally, at the end of each part, a brief literature review was provided with a specific focus on the impacts of these systems on different organizations and processes. The summary of the literature reviews is presented in Table 1.

4. Conclusion

Management information systems continue to exist as consultants worked with the users and administrators, despite the fact that rapid change and complexity are the era's defining characteristics. Because of these systems, analysis and data processing are both precise and lightning quick. It also has the ability to quickly formulate specific problems. Possible solutions are developed and evaluated so that the best choices can be made in a variety of contexts; these methods are then utilized. This paper has provided a review of the application of information systems. Six main types of IS were discussed focusing on the organization levels which they support. Their specific types, roles, advantages and limitations, and models are also highlighted.

These systems help companies for different purposes. DPSs such as transaction processing and electronic data interchange systems help companies with different transaction services. PCSs are employed aiming to monitor and control different processes. EIS collects different types of systems together and includes resource planning, customer relationship, knowledge, and supply chain management services. Management information systems aim to quickly prepare information while providing appropriate qualities to the users. The focus of DSS is on unique and fast-changing problems, to gain a solution for these kinds of issues. Finally, in contrast to DSS, executive information systems serve top managers directly by providing the most critical information. To sum up, a brief literature review was also added to provide a better understanding of IS impacts on different parameters such as the productivity, growth, and efficiency of the companies. The results of this review demonstrate the positive impacts of IS on businesses.

Conflicts of interest

The author declares no competing financial interest.

References

[1]   Laudon KC, Laudon JP. *Management Information Systems*. Managing the digital firm: Pearson Educación; 2019.
[2]   Asemi A, Safari A, Zavareh AA. The role of Management Information System (MIS) and Decision Support System (DSS) for manager's decision making process. *International Journal of Business and Management*. 2011; 6(7): 164-173.
[3]   Al-Mamary YH, Shamsuddin A, Aziati N. The role of different types of information systems in business organizations: A review. *International Journal of Research*. 2014; 1(7): 333-339.
[4]   Gray J, Reuter A. *Transaction Processing: Concepts and Techniques*. Elsevier; 1992.
[5]   Taherdoost H. Understanding cybersecurity frameworks and information security standards-A review and comprehensive overview. *Electronics*. 2022; 11(14): 2181. Available from: doi: 10.3390/electronics11142181.
[6]   Özkan S, Bindusara G, Hackney R. Facilitating the adoption of e-payment systems: theoretical constructs and empirical analysis. *Journal of Enterprise Information Management*. 2010.
[7]   Amin MB, Alauddin M, Azad MM. Business transaction processing system. *International Journal of Computer Information Systems*. 2012; 4(5): 11-60.
[8]   Azad MM, Amin MB, Alauddin M. Executive information system. *International Journal of Computer Science and Network Security*. 2012; 12(5): 106-110.
[9]   Matsuoka S, Muraki M. Implementation of transaction processing technology in permit-to-work systems. *Process*

Safety and Environmental Protection. 2002; 80(4): 204-210.

[10] Wang Y, Kogan A. Designing confidentiality-preserving Blockchain-based transaction processing systems. *International Journal of Accounting Information Systems*. 2018; 30: 1-18.

[11] Taherdoost H. A critical review of blockchain acceptance models-blockchain technology adoption frameworks and applications. *Computers*. 2022; 11(2): 24.

[12] Klapita V. Implementation of electronic data interchange as a method of communication between customers and transport company. *Transportation Research Procedia*. 2021; 53: 174-179.

[13] Taherdoost H, Sahibuddin S, Jalaliyoon N. A review paper on e-service; technology concepts. *Procedia Technology*. 2015; 19: 1067-1074.

[14] Bergeron F, Raymond L. The advantages of electronic data interchange. *ACM SIGMIS Database: the DATABASE for Advances in Information Systems*. 1992; 23(4): 19-31.

[15] Norris DM, Waples E. Control of electronic data interchange systems. *Journal of Systems Management*. 1989; 40(3): 21.

[16] Taherdoost H. Understanding of e-service security dimensions and its effect on quality and intention to use. *Information and Computer Security*. 2017; 25(5): 535-559.

[17] O'Callaghan R, Kaufmann PJ, Konsynski BR. Adoption correlates and share effects of electronic data interchange systems in marketing channels. *Journal of Marketing*. 1992; 56(2): 45-56.

[18] Frank C, Marchewka JT. Project zenith: A case study of electronic data interchange. *Communications of the IIMA*. 2004; 4(2): 2.

[19] Chuma LL. *The Role of Information Systems in Business Firms Competitiveness*. Integrated Review Paper from Business Perspective. 2020.

[20] Ciortea M. Aspects regarding the types of process control systems. *International Conference on Theory and Applications of Mathematics and Informatics*. 2004.

[21] Aubrun C, De Cuypere P, Sauter D. Design of a supervised control system for a sludge dewatering process. *Control Engineering Practice*. 2003; 11(1): 27-37.

[22] Mandel AS, Belyakov AG, Semenov DA. Expert-statistical processing of data and the method of analogs in solution of applied problems in control theory. *IFAC Proceedings Volumes*. 2008; 41(2): 3180-3185.

[23] Straut CM, Nelson A. Improving chemical security with material control and accountability and inventory management. *Journal of Chemical Education*. 2020; 97(7): 1809-1814.

[24] Azevedo PS, Romão M, Rebelo E. Advantages, limitations and solutions in the use of ERP systems (enterprise resource planning)-A case study in the hospitality industry. *Procedia Technology*. 2012; 5: 264-272.

[25] AboAbdo S, Aldhoiena A, Al-Amrib H. Implementing Enterprise Resource Planning (ERP) system in a large construction company in KSA. *Procedia Computer Science*. 2019; 164: 463-470.

[26] Aslan B, Stevenson M, Hendry LC. The applicability and impact of Enterprise Resource Planning (ERP) systems: Results from a mixed method study on Make-To-Order (MTO) companies. *Computers in Industry*. 2015; 70: 127-143.

[27] Taherdoost H, Keshavarzsaleh A. How to lead to sustainable and successful IT project management? Propose 5Ps guideline. *International Journal of Advanced Computer Science and Information Technology*. 2015; 4(1): 14-37.

[28] Hietala H, Päivärinta T. Benefits realisation in post-implementation development of ERP systems: A case study. *Procedia Computer Science*. 2021; 181: 419-426.

[29] Choi W, Rho MJ, Park J, Kim K-J, Kwon YD, Choi IY. Information system success model for customer relationship management system in health promotion centers. *Healthcare Informatics Research*. 2013; 19(2): 110-120.

[30] Kumar V, Reinartz W. *Customer Relationship Management*. Springer; 2018.

[31] King SF, Burgess TF. Understanding success and failure in customer relationship management. *Industrial Marketing Management*. 2008; 37(4): 421-431.

[32] Ku EC. The impact of customer relationship management through implementation of information systems. *Total Quality Management*. 2010; 21(11): 1085-1102.

[33] Haislip JZ, Richardson VJ. The effect of Customer Relationship Management systems on firm performance. *International Journal of Accounting Information Systems*. 2017; 27: 16-29.

[34] Li Y, Huang J, Song T. Examining business value of customer relationship management systems: IT usage and two-stage model perspectives. *Information & Management*. 2019; 56(3): 392-402.

[35] Lu D. *Fundamentals of Supply Chain Management*. Bookboon; 2011.

[36] Taherdoost H, Keshavarzsaleh A. A theoretical review on IT project success/failure factors and evaluating the

associated risks. *14th International Conference on Telecommunications and Informatics; August 17-19; Sliema, Malta*. Mathematical and Computational Methods in Electrical Engineering. 2015. p. 80-88.

[37] van der Vorst JG. *Supply Chain Management: Theory and Practices*. Bridging Theory and Practice: Reed Business; 2004. p. 105-128.

[38] de Camargo Fiorini P, Jabbour CJC. Information systems and sustainable supply chain management towards a more sustainable society: Where we are and where we are going. *International Journal of Information Management*. 2017; 37(4): 241-249.

[39] Nürk J. Smart information system capabilities of digital supply chain business models. *European Journal of Business Science and Technology*. 2019; 5(2): 143-184.

[40] Gresty M. What role do information systems play in the knowledge management activities of SMEs? *Business Information Review*. 2013; 30(3): 144-151.

[41] Abdullah R, Ibrahim H, Atan R, Napis S, Selamat MH, Hairudin N, et al. The development of bioinformatics knowledge management system with collaborative environment. *International Journal of Computer Science and Network Security*. 2008; 8(2): 309-319.

[42] Choi B, Poon SK, Davis JG. Effects of knowledge management strategy on organizational performance: A complementarity theory-based approach. *Omega*. 2008; 36(2): 235-251.

[43] Centobelli P, Cerchione R, Esposito E. Efficiency and effectiveness of knowledge management systems in SMEs. *Production Planning & Control*. 2019; 30(9): 779-791.

[44] Al-Mamary YH, Shamsuddin A, Aziati N. The meaning of management information systems and its role in telecommunication companies in Yemen. *American Journal of Software Engineering*. 2014; 2(2): 22-25.

[45] Rhodes J. *The role of management information systems in decision making*. eHow. 2010. Available from: http://www.eHow.com/facts 7147006 role-information-systems Decision-making.html [Accessed 23rd August 2022].

[46] Singh K, Kaur B. Role of Management Information System in Business: Opportunities and Challenges. *Gian Jyot E-Journal*. 2012; 1(2).

[47] Kock A, Schulz B, Kopmann J, Gemünden HG. Project portfolio management information systems' positive influence on performance–the importance of process maturity. *International Journal of Project Management*. 2020; 38(4): 229-241.

[48] Jain R, Raju S. *Decision Support System in Agriculture Using Quantitative Analysis*. Udaipur: Agrotech Publishing Academy; 2016.

[49] Holsapple CW. DSS architecture and types. *Handbook on Decision Support Systems 1*. Springer; 2008. p. 163-189.

[50] Erozan İ. A fuzzy decision support system for managing maintenance activities of critical components in manufacturing systems. *Journal of Manufacturing Systems*. 2019; 52: 110-120.

[51] Guo Y, Wang N, Xu Z-Y, Wu K. The internet of things-based decision support system for information processing in intelligent manufacturing using data mining technology. *Mechanical Systems and Signal Processing*. 2020; 142: 106630. Available from: doi: 10.1016/j.ymssp.2020.106630.

[52] Teerasoponpong S, Sopadang A. Decision support system for adaptive sourcing and inventory management in small-and medium-sized enterprises. *Robotics and Computer-Integrated Manufacturing*. 2022; 73(3): 102226. Available from: doi: 10.1016/j.rcim.2021.102226.

[53] Salmeron JL, Luna P, Martinez FJ. Executive information systems in major companies: Spanish case study. *Computer Standards & Interfaces*. 2001; 23(3): 195-207.

[54] Shim JK. *Information Systems and Technology for the Noninformation Systems Executive: an Integrated Resource Management Guide for the 21st Century*. CRC Press; 2000.

[55] Leidner DE, Elam JJ. Executive information systems: their impact on executive decision making. *Journal of Management Information Systems*. 1993; 10(3): 139-155.

[56] Florentino T, Joyanes L. The impacts of an executive information system on an insurance company in portugal. *International Association for Development of the Information Society Proceedings of IADIS International Conference-Applied Computing*. 2004; 297-304.